72-29,914

STARK, Jr., James Jehu, 1929-
THE PROBLEM SOLVING ABILITY OF A GROUP OF
HARD OF HEARING CHILDREN OF AVERAGE INTELLIGENCE.

The University of Oklahoma, Ph.D., 1972
Education, special

University Microfilms, A XEROX Company, Ann Arbor, Michigan

THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

THE PROBLEM SOLVING ABILITY OF A GROUP OF HARD OF HEARING CHILDREN OF AVERAGE INTELLIGENCE

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

DOCTOR OF PHILOSOPHY

BY

JAMES J. STARK, JR.

1972

THE PROBLEM SOLVING ABILITY OF A GROUP OF

HARD OF HEARING CHILDREN OF

AVERAGE INTELLIGENCE

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ACKNOWLEDGMENTS

The author wishes to express his gratitude to Dr. P. T. Teska, who directed this study, for providing the equipment for this study, and for his guidance.

The author also wishes to thank Dr. Omer J. Rupiper, Dr. Mary Clare Petty, and Dr. Bonnie Roberts for their assistance and encouragement, and for their willingness to serve as members of the committee.

The author also wishes to express gratitude to Dr. Paul Allen Heath for his help and support.

Acknowledgment is made to Mr. Jim Schmaelze, Principal of the University of Oklahoma Medical Center School for the Deaf, and to Mrs. Jane Harris, Director of the Jane Brooks School for the Deaf, for their cooperation in allowing this study to be made in their schools, and to Mrs. Judy Smith for her assistance in gathering the data.

The author wishes to thank his wife, Geneva, his sons, James III, and Stephen, and his daughters, Peggy and Marilyn, for their patience and encouragement.

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CHAPTER I

INTRODUCTION

Deafness is a language handicap. Deafness can be defined as hearing loss of sufficient degree that it leaves the individual incapable of understanding spoken language or developing oral communications unless specially trained. Those persons who have such severe hearing loss and who have been deprived of language experiences during the formative years provide unique opportunities for impartial study of performance on nonverbal cognitive tasks.

In the hearing child, hearing and seeing complement each other in helping the child understand and cope with his total environment. Vision is a directional, relating the child to the objects and activities before him; hearing is a non-directional, extending to the total environment and operating continuously. The child with little or no hearing must utilize kinesthetic and visual senses in place of hearing. His total sensory experience is thus modified and limited.

Psychologically, there is a difference between the hearing child and the child with severe hearing loss, for the experiences of the latter child are gained through four instead of five senses. This does not mean that this child is inferior to the hearing child, but it implies that there is a difference in his qualitative mental development. His experiences would have been more evenly balanced if he had possessed an adequate sense of hearing.

For the purpose of this study, the term "hard of hearing child" was defined as a child who is incapable of understanding spoken language or developing oral communication unless specially trained, or as one who has demonstrated that he, because of his hearing loss, cannot profit from programs available to him in regular schools. The term "deaf child" is used by many of those in the deaf education profession in a very restrictive sense: it indicates little or no residual hearing at any frequency. With the recent development of more sophisticated techniological equipment and improved methods, audiologists are finding only a small number of deaf children.

Consequently, there is a trend among those in this profession to use the terms "hard of hearing child," "hearing impaired child," or "hearing handicapped child" to identify a child with severe hearing loss. This study is concerned with the problem solving ability of a group of hard of hearing children of average intelligence.

P. T. Teska[1] presents a very extensive review of the literature of problem solving and the problem solving process. He states that, "If a test of problem solving is to include exercise of the complete problem solving process, it should include: first, a problem situation in which the perception of the problem is possible and the need or desire for its solution is established; second, data of such a nature that it will yield to isolation, definition, and organization to the extent that generalizations may be made inductively; third, a solution which can be arrived at through hypotheses growing out of the analysis and organization of the data; and fourth, a means of systematically checking hypotheses deductively against the data."[2]

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[1] P. T. Teska, "Performance of Dull and Bright Children in a Non-Language Multi-Choice Problem Situation," (Unpublished Ph.D. Dissertation, University of Wisconsin, 1942), p. 1-26.

[2] _Ibid_., p. 5.

Hensley[1] reviewed the various methods of testing problem solving ability. He concluded that problem solving using multiple choice techniques appeared to be adequate for testing people of all chronological ages for problem solving ability since it included the complete problem solving process. Heath[2] accepted the problem solving criteria. From his study he concluded that problem solving using the multiple choice technique appeared to be adequate for testing children from various socio-economic levels for problem solving ability.

H. G. Furth[3] suggested that the relationship of language to cognitive development presents an intriguing problem for investigation. Citing Piaget's theory that cognitive development changes with age and experience and develops through activity, Furth suggested that cognitive growth is not dependent upon language behavior. Furth reported that Goodnow, Lovell, and Ogilvie corroborate the view that kind of experience with the physical world, rather than language or

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[1]Horace Gene Hensley, "A Comparative Study in Problem Solving of Bright and Dull Children," (Unpublished Ph.D. Dissertation, University of Oklahoma, 1957), pp. 2-19.

[2]Paul Allen Heath, "A Comparative Study in Problem Solving Ability of a Group of Negro and White Children of Average Intelligence by Socio-Economic Level," (Unpublished E.D. Dissertation, University of Oklahoma, 1970), pp. 1-6.

[3]H. G. Furth, "Research with the Deaf: Implications for Language and Cognition," Psychological Bulletin, Vol. LXII, No. 3, (September, 1964), p. 145.

formal training, determines in part the child's age at which he moves from a perceptual to a logical judgment on many Piaget-type experiments.[1] From this, Furth theorized that deaf children would not differ from hearing children with respect to the age at which problem solving ability develops.

Furth reported that the performance of deaf children on some of Piaget's familiar conservation problems was tested by Oleron and Herren. They produced a group of pictures which were used as substitutes for the words "heavier," "same," "lighter" for weight conservation, and "more," "less" for volume conservation. After training with these pictures, fifty percent of the deaf subjects succeeded on the weight problem at 8.5-years of age and fifty percent succeeded on the quantity of liquid problem at 10.5-years of age. This was about six years behind the age levels at which the hearing subjects succeeded on these tasks.[2]

Furth[3] realized that the use of the pictorial symbols might have created extra difficulties for the deaf subjects, so he taught them to use hand movements to serve as word substitutes, and then replicated Oleron and Herron's experiments.

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[1]Furth, op. cit., p. 156.

[2]Ibid. [3]Ibid.

He discovered that, when using his methods, the 8-year-old deaf children performed more like the 6.5-year-old hearing children. An investigation of failures indicated that a greater number of hesitant and inconsistent responses were made by the deaf 8-year-olds than by the 6-year-old hearing children, thus suggesting that the older deaf children were really closer to the correct solution than the mere number of successes or failures would indicate, but they felt uncomfortable about their responses.

Furth further reported that Oleron, in 1957, observed 33 deaf children, aged 4-7, on temporal and spatial order tasks. On the temporal task (a double and triple alternation problem) the deaf children were about 2 years behind the hearing children. No difference was shown between the deaf and hearing children in the discovery of spatial order.[1]

In 1961, Furth[2] anticipated that lack of language would not be a handicap to deaf children in attainment and use of the concept of Opposition, but would limit them in the discovery of the concepts of Sameness and Symmetry. He made a study of this premise and found no consistent difference on the concepts of Sameness and Symmetry; but on Opposition the deaf

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[1] Furth, *op. cit.*, p. 150.

[2] *Ibid.*

children, aged 7-12, did not function as well as the hearing children. He assumed that the constant use of opposites in verbal language gave the hearing children a distinct advantage. He felt that this was a good example of what Vygotsky called "pseudoconcepts" formed through linguistic usage, meaning verbal behavior in which the impression was given of the mastery of a certain concept but which, in reality, was determined by frequent linguistic associations.

Furth reported that further testing by Oleron (1962) on learning tasks based on the concepts of Sameness or Difference showed no appreciable differences between deaf and hearing children. Using a group of 38 deaf children and 38 hearing children, aged 4-7, and comparing their performance with stimulus-discrimination objects of shape, object, color, weight, size, or speed, he noted that a majority of both groups succeeded from 5 years of age upward.[1]

Furth further reported that Kendler and Kendler conducted studies of reversal-nonreversal shift performance with deaf children, which Russell replicated. Youniss (1964), employing and extending the design of two shift stages, found no differences between deaf and hearing children on the reversal shift performance part of the experiment. He felt

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[1]Furth, op. cit., p. 150.

that the studies indicated that lack of early linguistic experiences does not impede mediated behavior. Furth and Youniss studied 6- and 9-year-old hearing and deaf children in paired-associate learning of color and colored objects under reversed and control condition. They observed that the hearing childrens' performance was significantly worse in the reversal condition, and that the deaf children seemed to pay less attention to the color of the objects, so were not hindered too greatly when the natural colors were reversed.[1]

Furth cited that Chuillat and Oleron, using Rey's standardized test of practical intelligence, conducted a series of six experiments and observed that the tasks which were easy for the hearing children, aged 6-7, to solve were difficult or not solvable for the deaf school children, aged 5-12, even with the help of the experimenter. In a 1957 study done by Oleron, this extreme inferiority was not found. He found that deaf children, aged 5-7, solved a manipulatory problem and their solutions were very much like those of hearing children of their age in quantity and quality. He felt that his findings contradicted a rigid theory which linked language and practical intelligence.[2]

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[1] Furth, _op. cit._, p. 152.

[2] _Ibid._, p. 157.

Furth reported that O'Conner and Hermelin, in their study in 1965, observed visual-spatial analogies of operations required in linguistic competence, using tasks of seriation or ordering, sight and touch involved in rule discovery, immediate memory, and perceptual matching. Their control groups consisted of deaf, aphasic, and normal groups of children and their experimental groups consisted of psychotic and imbecile groups of children. Children aged 10-11 (N=12) were used. The three control groups succeeded equally well on all tasks, which seemed to indicate conclusively that the capability for manipulating symbols and signs is not dependent on speech or verbal comprehension, and that logic of thinking develops relatively independently.[1]

The review of literature indicates that there has been a substantial increase in research with the hard of hearing in recent years. However, the results of the research are very inconclusive and indicate that much more research is needed in all areas with the hard of hearing, particularly where the problems presented to them are constructed so that the solution to the problems involves the use of the four

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[1]H. G. Furth, "A Review and Perspective on the Thinking of Deaf People." Cognitive Studies, Vol. I. Edited by Jerome Hellmuth. New York: Brunner/Mazel, Inc., 1970, p. 321.

steps of the complete problem solving process, as stated by Teska.[1]

Statement of the Problem

From a review of the literature it is evident that only a few studies dealt directly with problem solving in which the solution necessitated the use of the complete problem solving process. The studies by Teska, Hensley, and Heath included this process but these studies did not include subjects known to have severe hearing loss. It is therefore appropriate to ask: (1) Has the language deficiency affected the hard of hearing child's cognitive development? (2) Can he organize his experiences on a meaningful, perceptual, and conceptual base? (3) Can he use, or does he use logical reasoning? (4) Can he remember things, and see important aspects of the whole? (5) Can he form theoretical judgments?

Purpose of the Study

The purpose of this study was to test, through the use of the Problem Box, (1) the problem solving ability of a group of hard of hearing children of average intelligence and (2) to compare the problem solving ability of this hard of

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[1] Ms., p. 3.

hearing group with the problem solving ability of a group of hearing children who were tested by Heath[1] through the use of the Problem Box in 1970. Heath's group was composed of three groups of children of average intelligence from the 2nd, 4th, and 6th grades in public schools who were from lower white, lower black, and higher white socio-economic levels. Heath's groups were treated as a single group (hereafter referred to as the hearing group) for the purpose of this comparison study, since Heath concluded:

> Statistically significant differences were not observed among the three groups for any of the ten problems. No one group was able to solve any of the ten problems significantly better than any other of the two groups; again revealing evidence that no differences existed in the problem solving ability of any of the three groups as measured by chi square proportions except those related to chance error.[2]

The problem solving ability of each subject was measured by his ability to solve each of the ten problems of the Problem Box; by the number of trials he required to solve each of the ten problems; and by his ability to solve each of the ten problems with a correct verbal generalization. The Problem Box used was designed by Teska and adapted by Heath.[3] For this study, electrical push button selectors were installed on

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[1]Heath, _op_. _cit_., pp. 9-11.

[2]_Ibid_., p. 32. [3]_Ibid_., pp. 13-15.

the front panel of the Problem Box to replace the four pull switches and a new set of slides was made. A full description of the Problem Box is given on page 16.

Hypotheses Tested

In this study, the following hypotheses, stated in the null form, were tested.

1. There is no statistically significant difference in the problem solving ability as measured by the number of the hard of hearing group versus the hearing group in solving or not solving each of the ten problems of the Problem Box.
2. There is no statistically significant difference in the problem solving ability as measured by the number of trials used by the hard of hearing group versus the hearing group to solve each of the ten problems of the Problem Box.
3. There is no statistically significant difference in the problem solving ability as measured by the number of the hard of hearing group versus the hearing group solving each problem by verbal generalization versus the necessary number of consecutive red lights criterion.

4. There is no statistically significant difference between the mean number of problems solved by the hard of hearing group and the hearing group.

Selection of Subjects

The hard of hearing children of average intelligence, aged 6.9 years to 12.11 years, used in this research were from the University of Oklahoma Medical Center School for the Deaf in Oklahoma City, Oklahoma, and the Jane Brooks School for the Deaf in Chickasha, Oklahoma. Before the research was started, a survey was made of classes for the hard of hearing in these two schools; in the public school systems of Oklahoma City, Tulsa, and Muskogee, Oklahoma; and in the Oklahoma School for the Deaf in Sulphur, Oklahoma. The principals of all of these schools expressed an interest in the project and a willingness to cooperate. However, the two schools indicated were selected because they emphasized the oral method of teaching the hard of hearing and they had very similar admission requirements. Some of these requirements were:[1]

1. The child must be "educationally deaf": That is, he is incapable of understanding spoken language and/or developing oral communications unless specially

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[1]"Eligibility for Enrollment," University of Oklahoma Medical Center School for the Deaf Bulletin, 1970, p. 2.

trained, or otherwise has demonstrated that he cannot profit, because of his hearing loss, from the programs available in the regular schools.

2. The child must obtain an otolaryngological examination by a competent specialist and forward a copy of the medical report to the school.

3. A complete audiological evaluation must be obtained.[1] If a hearing aid is recommended, provision must be made to obtain a personal instrument.

4. A prognostic education evaluation must be obtained by a competent psychologist who is familiar with the communicative problems of deafness. The child must be in possession of a level of learning ability which will permit him to benefit from the oral school program.

5. Deafness must be the major handicapping factor. Deaf children with secondary handicaps may be accepted, depending upon the nature of the secondary handicap and the capacity of the School's personnel and facilities to provide for it.

The problem solving ability of the hard of hearing subjects was compared with that of the hearing subjects tested by Heath in 1970. For his study, Heath selected eighty-four subjects of average intelligence from the 2nd, 4th, and 6th grades, whose ages ranged from 7.5-years to 12.9-years. These subjects were selected from a compiled Master List of elementary schools in the Oklahoma City, Oklahoma, Public School System, I-89, which were designated as serving lower black

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[1] Ms., Appendix, Table 8.

socio-economic, lower white socio-economic, or higher white socio-economic levels of population.[1]

Limitations

This study was limited to forty-four hard of hearing children, aged 6.9-years to 12.11-years, of average intelligence, attending the University of Oklahoma Medical School for the Deaf, and the Jane Brooks School for the Deaf, who were tested for problem solving ability through the use of the Problem Box. The experimenter purposely chose children only from these two schools for the deaf because they had similar educational philosophies and they both used the oral method of teaching. Types of data receiving special attention were: (1) Number of subjects solving each of the ten problems; (2) Number of trials used by the group to solve each of the ten problems; (3) Number of subjects solving each of the ten problems by verbal generalization; and (4) Mean number of problems solved.

Definitions

Definitions of terms used in this study are as follows:

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[1] Heath, op. cit., p. 9.

Hard of Hearing: A hearing loss of sufficient degree that leaves the individual incapable of understanding spoken language or developing oral communications unless specially trained.

Hard of Hearing Child: A child who is educationally hard of hearing; that is, he is incapable of understanding spoken language, or developing oral communication unless specially trained, or he has demonstrated that he cannot profit from programs available in the regular school because of his hearing loss.

Problem Solving Ability: The mental process used in achieving the solution to a problem, using both inductive and deductive reasoning.

Problem Box: The testing apparatus designed by P. T. Teska[1] and adapted by Heath,[2] as described below.

The Problem Box

The Problem Box was 10" high, 20" wide, and 30" long. Inside the box was a 35mm Kodak 850 projector. A pre-selected series of slides of a square and a triangle in any one of eight different positional relationships were projected on a 4½"

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[1]Teska, op. cit., pp. 28-29.

[2]Heath, op. cit., pp. 13-14.

square screen located in the front panel of the box. On the right and left sides of the screen were an upper and lower push button. Directly above the screen was a small, round, unlighted bulb which became a red light when the correct button was pushed for each of the trials. Built into the electrical mechanism of the Problem Box were nine series of objective answers which made it possible to present to the subject sets of twenty consecutive but different trials for each problem. The Problem Box was designed so that the slides automatically changed five seconds after any button was pushed by the subject. If the correct button for that trial was pushed, the red light also came on, indicating a correct solution. After the five-second interval, the red light went off and the next set of figures appeared on the screen. By using Teska's original problems,[1] the subject was able to demonstrate his problem solving ability through the use of a nonverbal task without being aided or hindered by his previous reading, vocabulary, and other language skills.

Test Procedure

The following operational rules were made: (1) A maximum number of eighty consecutive trials were allowed each

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[1]Teska, *op. cit.*, p. 37.

subject for each of the ten problems; (2) Two types of solutions were considered acceptable for a correct response: a given problem was considered solved after the necessary number of consecutive red lights were obtained, or after the subject had volunteered a correct verbal generalization; (3) The tester recorded the exact response for every slide on a standard answer sheet printed for each of the ten problems for each subject. He also recorded the words used in the verbal generalizations and any other non-verbal clue given in regard to the solution of the problem and marked the square at the bottom of the answer sheets as to whether or not he felt that the subject understood how he was making the red light come on every time; (4) No session was terminated until the subject had been given an opportunity to attempt to solve all ten problems; (5) Each subject was given the same directions, with a demonstration on the first problem and all problems were presented in identical order.

The subject was given these directions by pantomime and by spoken instructions: "One of these four buttons (the examiner placed a finger on each button in turn) will make this red light come on." The examiner illustrated this by pushing the correct button for the solution for the first problem (the button by the side of the square), causing the red light to come on. He continued, "After the button is pushed, the light and the figures will stay on the screen for five seconds; then the light will go out and new figures will appear on the screen." After the directions and pantomime had been repeated, the subject was told: "Now you push the button that will make the red light come on every time." After at least eighteen trials, or when it was obvious from the subject's performance that he had not comprehended the directions, he was given another demonstration like the first one. If the subject had not solved the demonstration problem after eighty consecutive trials, he was told the solution; then the series of problems was continued.

On problems one through nine, lighting ten consecutive red lights gave a passing score. On problem ten, however, lighting fifteen consecutive red lights was necessary for a passing score (without correct verbal generalization) because, due to the arrangement of the slides, the criterion for solving problem nine could have been incorrectly applied and could have resulted in ten consecutive red lights without actually having reached the correct solution for problem ten.

When the subject had lighted the necessary number of consecutive red lights and had not volunteered a verbal solution of the problem, the examiner gave the subject an opportunity to verbalize his solution by asking, "You are making the red light come on every time: How do you do it?" or, "How do you know which button to push to make the red light come on?"

The following problems were used to test for problem solving ability:

1) always the square (demonstration problem)
2) always the triangle
3) always the figure to the left
4) always the green figure
5) triangle when both figures are red; square when both figures are green
6) always the figure on the right--but in each trial one figure was red, one was green; the color was a false clue which must be disregarded in the solution
7) red-green alternation, regardless of figure
8) square when both figures are red; triangle when both figures are green
9) single alternation with both figures appearing red or both figures appearing green, color being a false clue to be disregarded in the solution

10) square when figures are in opposite corners; triangle when the figures are in adjacent corners.

The primary data for this study was gathered from the answer sheets marked for the hard of hearing subjects tested. The data gathered by Heath for the hearing group was adjusted from 100 to 80 trials per problem for this study.

CHAPTER II

RESULTS

Forty-four hard of hearing children of average intelligence were used as subjects in this study. This group was tested through the use of the Problem Box, and the results of the testing are presented in tabular form. Tables 1 through 7 show: (1) Chi Square tests on 2 x 2 contingency tables for each of the ten problems on a simple pass-failure basis. (2) Mean and Standard Deviation of the number of trials to solve each problem for the hard of hearing and the hearing samples. (3) Chi Square tests for the 2 x 2 contingency tables for the subjects from each sample passing the problem by either verbal generalization or the necessary number of consecutive red lights. (4) Sex, chronological age, number of trials per problem, total trials used, and mean number of trials used, for each of the hard of hearing subjects. (5) Percentage of the hard of hearing group passing each problem, with the problems listed in the rank order of their difficulty of solution from the highest to the lowest percentage of the group solving each problem, showing the mean number of trials used by the group and standard deviation for each problem. (6) Numbers of problems solved and total number of problems solved by each of the hard of hearing subjects on a simple pass-failure basis. (7) Numbers of problems solved and total number of problems solved by verbal generalization by each of the hard of hearing subjects.

Analysis of Data

Hypotheses one and three were tested by applying the Chi Square test for 2 x 2 contingency tables. The basic computation formula used was found in Fundamental Statistics in Psychology and Education, by J. P. Guilford,[1] on page 239. When the Expected Frequency was less than 10 and the degree of freedom = 1, then Yates's correction for continuity was applied, as cited by Guilford.[2] This correction consists in reducing by 0.5 each obtained frequency that is greater than expected and in increasing by the same amount each frequency that is less than expected. This has the effect of reducing the amount of each difference between obtained and expected frequency to the extent of 0.5. The result is reduction of

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[1] J. P. Guilford, Fundamental Statistics in Psychology and Education, New York: McGraw Hill Book Co., 1965, p. 239.

[2] Ibid., p. 237.

the size of the Chi Square. When Yates's correction for continuity was applied, the formula cited by Guilford[1] was used.

Hypotheses two and four were tested at the .05 significant level using a t-test between independent samples. The basic computation formula was used as cited by Guilford.[2] Hypothesis two was tested using a t-test for significance at the .05 level for the mean number of trials for each of the ten problems. Hypothesis four was tested using a t-test for significance at .05 level between the two groups in the mean number of problems solved.

Statistical Interpretation of Data

The Chi Square analysis results presented in Table 1 relate to hypothesis 1. This hypothesis states that the number passing or failing an item from the hard of hearing group or the hearing group is the same, i.e., does not differ statistically at the .05 significance level. This general hypothesis is rejected for problems 3, 6, and 10 ($x^2 = 3.84$; df - 1; $p < .05$). For the significantly different problems (3, 6, and 10) the hard of hearing group had a higher number of subjects solving the problem than did the hearing group.

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[1] Guilford, op. cit., p. 240. [2] Ibid., p. 183.

Table 1: Chi Square Tests on 2 x 2 Contingency Tables for Each of the Ten Problems on a Simple Pass-Failure Basis

	Pass	Fail	Total	
<u>Problem 1</u>				
Hard of Hearing	38	6	44	
Hearing	60	24	84	Chi Square = 3.59
Total	98	30	128	
<u>Problem 2</u>				
Hard of Hearing	44	0	44	
Hearing	82	2	84	Chi Square = 1.06
Total	126	2	128	
<u>Problem 3</u>				
Hard of Hearing	34	10	44	
Hearing	45	39	84	Chi Square = 6.87*
Total	79	49	128	
<u>Problem 4</u>				
Hard of Hearing	44	0	44	
Hearing	81	3	84	Chi Square = 1.61
Total	125	3	128	
<u>Problem 5</u>				
Hard of Hearing	33	11	44	
Hearing	56	28	84	Chi Square = 0.95
Total	89	39	128	

* $p < .05$.

Table 1--(Continued)

	Pass	Fail	Total	
Problem 6				
Hard of Hearing	37	7	44	
Hearing	54	30	84	Chi Square = 5.51*
Total	91	37	128	
Problem 7				
Hard of Hearing	14	30	44	
Hearing	37	47	84	Chi Square = 1.80
Total	51	77	128	
Problem 8				
Hard of Hearing	25	19	44	
Hearing	62	22	84	Chi Square = 3.83
Total	87	41	128	
Problem 9				
Hard of Hearing	25	19	44	
Hearing	48	36	84	Chi Square = 0.001
Total	73	55	128	
Problem 10				
Hard of Hearing	28	16	44	
Hearing	16	68	84	Chi Square = 25.45*
Total	44	84	128	

* $p < .05$.

Hypothesis 2 related to the number of trials required to solve each problem. Table 2 summarizes these data separately for the hard of hearing and the hearing groups, respectively. Means vary from a low of 7.73 trials for the hard of hearing group on problem 4 to 72.53 trials on the tenth problem by the hearing group. Although the standard deviations vary between problems, they are fairly homogeneous between groups for the same problems. The size of a number of the standard deviations indicate skewed distributions, but this lack of normality has very little effect on the t statistic as found by Boneau.[1]

The significant t-ratio for problems 1, 3, 4, 6, and 10 all indicate fewer trials to solution for the hard of hearing group. The t-ratio of 1.97 for problem 8 is only .01 unit less than the required 1.98 at the .05 significance level. This relationship favors the hearing group, i.e., fewer trials are required for solution.

For hypothesis 3, Table 3 summarizes the 2 x 2 contingency tables and the Chi Square values for each of the problems. These data represent a comparison of the hard of hearing and hearing subjects who passed each problem. A

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[1]C. A. Boneau, "The Effects of Violations of Assumptions Underlying the t-test," Psychological Bulletin, 57, 1960, pp. 49-64.

Table 2. Mean and Standard Deviation of the Number of Trials to Solve Each Problem for the Hard of Hearing and Normal Hearing Samples

Group		Problem									
		1	2	3	4	5	6	7	8	9	10
Hard of Hearing (N=44)	Mean	25.68	8.48	48.14	7.73	37.70	37.48	67.89	48.16	53.16	56.61
	S.D.	27.35	10.75	24.89	9.30	28.72	26.83	21.02	31.28	28.18	24.15
Hearing (N=84)	Mean	46.02	12.32	60.90	14.99	44.63	52.46	61.01	39.96	52.74	72.53
	S.D.	26.75	11.19	22.38	14.66	29.12	25.64	25.35	28.26	27.73	17.55
t-ratio		3.99*	1.88	2.82*	3.39*	1.28	3.02*	1.62	1.97**	0.08	3.83*

* $p < .05$
** Very close to significance;
Minimum t required at .05 level with 126 d.f. = 1.98.

problem could be passed in one of two ways: by selecting the necessary number of consecutive red lights or by giving a verbal generalization evidencing an understanding of the solution. For example, on problem 1, 38 hard of hearing subjects passed, 35 by verbal generalization and 3 by the consecutive red lights criterion; and 60 hearing subjects passed, 58 by making a correct verbal generalization and 2 by the consecutive red lights criterion. When submitted to Chi Square analysis, these data yielded a computed value of 1.00.

For problems 2, 5, 7 and 9 the expected frequency was less than 10, so Yates's correction for continuity was applied. The correction was not applied for data of other problems since the correction lowers the value of Chi Square and the Chi Square values for these problems were already below the 3.84 value required as a minimum for significance when there is 1 df at the .05 significance level. Only problems 5, 7, and 9 yielded significant Chi Square values in the number of subjects solving the problems by verbal generalization versus the consecutive red lights criterion. In each instance, the hearing group had a greater number of subjects solving problems 5, 7, and 9 by verbalization.

It can be inferred that the statistically significant differences on Problems 5, 7, and 9, pertaining to the verbal

Table 3: Chi Square Tests for the 2 x 2 Contingency Tables for the Subjects from Each Sample Passing the Problem by Either Verbal Generalization or the Necessary Number of Consecutive Red Lights

	Verbal Generalization	Consecutive Red Lights	Total	
Problem 1				
Hard of Hearing	35	3	38	Chi Square = 1.00
Hearing	58	2	60	
Total	93	5	98	
Problem 2				
Hard of Hearing	40	4	44	
Hearing	81	1	82	Chi Square = 2.82
Total	121	5	126	
Problem 3				
Hard of Hearing	25	9	34	
Hearing	34	11	45	Chi Square = 0.04
Total	59	20	79	
Problem 4				
Hard of Hearing	40	4	44	
Hearing	78	3	81	Chi Square = 1.57
Total	118	7	125	
Problem 5				
Hard of Hearing	25	8	33	
Hearing	53	3	56	Chi Square = 5.20*
Total	78	11	89	

* $p < .05$.

Table 3--(Continued)

	Verbal Generalization	Consecutive Red Lights	Total	
Problem 6				
Hard of Hearing	30	7	37	
Hearing	43	11	54	Chi Square = 0.03
Total	73	18	91	
Problem 7				
Hard of Hearing	9	5	14	
Hearing	37	0	37	Chi Square = 10.89*
Total	46	5	51	
Problem 8				
Hard of Hearing	19	6	25	
Hearing	55	7	62	Chi Square = 2.26
Total	74	13	87	
Problem 9				
Hard of Hearing	14	11	25	
Hearing	41	7	48	Chi Square = 6.15*
Total	55	18	73	
Problem 10				
Hard of Hearing	8	20	28	
Hearing	3	13	16	Chi Square = 0.52
Total	11	33	44	

* $p < .05$.

generalizations of the solutions, occurred with the hard of hearing subjects as a result of the inadequacy of their linguistic ability to verbalize the concepts of alternation as presented by these three problems, since the hard of hearing group demonstrated their problem solving ability on these problems by solving them by using the consecutive red lights criterion.

Hypothesis 4 related to possible differences in the mean number of problems solved between the two groups. An analysis of these data revealed that the hard of hearing group had a mean of 7.32 problems solved with a standard deviation of 1.79 as compared to a mean of 6.44 problems solved with a standard deviation of 1.95 by the hearing group. When submitted to a t-test between independent samples, a value of 2.53 was obtained. This computed value was larger than the minimum value of 1.97 required to reject the null hypothesis at the .05 significance level.

Therefore it can be inferred that the hard of hearing group, when tested by the Problem Box, had a significantly greater ability in solving problems of cognition which depend upon the complete problem solving process and upon visual perceptive faculties. This may be attributed to their life-long dependency upon visual senses and to their lack of audio distractions when performing these visual perceptual cognitive problem solving tasks.

Analyses of the problem solving ability of the hard of hearing subjects and the hearing subjects presented in this research suggested some interesting relationships:

1. Where statistically significant differences occurred in the number of hard of hearing subjects passing as compared to the number of hearing subjects passing (problems 3, 6, and 10) the hard of hearing group produced a higher number of passes.
2. Significant differences in the mean number of trials used in solving problems 1, 3, 4, 6 and 10 indicated fewer trials were required by the hard of hearing subjects than by the hearing subjects.
3. On problems where statistically significant differences occurred between the number of hard of hearing subjects and hearing subjects in the way they solved the problems (problems 5, 7 and 9) the hard of hearing subjects solved a greater number of problems by the consecutive red lights criterion without making a correct verbal generalization.
4. The hard of hearing group solved significantly more problems than did the hearing group when considered

4. (Continued)--on a simple pass-failure basis.

Observations

Several observations can be made about the performance of the hard of hearing children. Table 4 (Appendix, p. 46) shows that the hard of hearing children used a mean number of 391.02 total trials to solve the ten problems. In considering the mean number of trials used by this group to solve each problem, it is apparent that certain problems were more easily solved than others. The problems listed in the rank order of their difficulty of solution for the hard of hearing group from the one requiring the smallest mean number of trials to the one requiring the largest mean number of trials were found to be: Problem 4 (always the green figure--7.73 mean number of trials; Problem 2 (always the triangle)--8.48 mean number of trials; Problem 1 (demonstration problem, always the square)--25.68 mean number of trials; Problem 6 (always the figure on the right, with color a false clue)--37.48 mean number of trials; Problem 5 (triangle when both figures red; square when both figures green)--37.70 mean number of trials; Problem 3 (always the figure on the left)--48.14 mean number of trials; Problem 8 (square when both figures red; triangle when both figures green)--48.16 mean number of trials; Problem 9 (single alternation with both figures appearing red or both figures appearing green, color being a false clue)--53.16 mean number of trials; Problem 10 (square when figures are in opposite corners; triangle when figures are in adjacent corners)--56.61 mean number of trials; Problem 7 (red-green alternation, regardless of figure)--67.89 mean number of trials. The rank order of difficulty of the problems varied between the hard of hearing group and the hearing group. The order for the hard of hearing group was found to be: 4, 2, 1, 6, 5, 3, 8, 9, 10, 7; and for the hearing group: 2, 4, 8, 3, 5, 1, 6, 7, 9, 10.[1]

Table 5 (Appendix, p.49) shows the percentage of the hard of hearing group passing each problem, with the problems listed in rank order from the highest to the lowest percentage of the group solving each problem, showing the mean number of trials used by the group in solving each problem. This table reveals that 100 percent of the hard of hearing subjects solved Problem 2 and Problem 4, but Problem 2 was more difficult for them to solve. Problem 7, which was the most difficult for this group, was solved by 31.1 percent

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[1]Heath, op. cit., p. 32.

of the group. Both Problem 8 and Problem 9 were solved by 56.8 percent of the group, but Problem 9 was the more difficult of the two for them to solve.

Table 6 (Appendix, p. 50) shows that, on a simple pass-failure basis, the hard of hearing group solved a mean number of 7.32 problems. All of the hard of hearing subjects were able to solve four or more of the ten problems. Utilization of Table 6 and Table 7 (Appendix, p. 51), together shows that six of the subjects solved all of the ten problems in the following ways: Subjects 4, 16, and 40 gave correct verbal generalizations for all ten problems; Subject 35 gave correct verbal generalizations for nine problems and consecutive red lights for one problem; Subject 42 gave correct verbal generalizations for eight problems and consecutive red lights for two problems; and Subject 8 gave verbal generalizations for seven problems and consecutive red lights for three problems. Subject 13 and Subject 14 solved seven problems, and eight problems, respectively, using only the consecutive red light criterion, with no problems solved by verbal generalization.

CHAPTER III

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

Through the use of the Problem Box, the examiner tested the problem solving ability of a group of hard of hearing children. Forty-four hard of hearing children of average intelligence between the ages of 6.9 years and 12.11 years from the University of Oklahoma Medical Center School for the Deaf, Oklahoma City, Oklahoma, and the Jane Brooks School for the Deaf, Chickasha, Oklahoma, were tested. The problem solving ability of this group was compared with the problem solving ability of eighty-four hearing children of average intelligence between the ages of 7.5 years and 12.9 years who were similarly tested by Heath in 1970.

The Problem Box is the testing apparatus designed by Teska and adapted by Heath which presented, on a screen in the front panel of the Problem Box, a pre-selected series of slides of a square and a triangle in any one of eight different positional relationships. Four electrical push buttons were positioned around the screen and the subject was told to push the button that would make the small red light above the screen come on every time.

Two types of solutions were considered acceptable for a correct response: verbal generalization of the correct solution, or selection of the necessary number of consecutive red lights. The subject was given an opportunity to verbalize his solution to each problem. The problems of the Problem Box were constructed so that the correct solution required that the subject perceive the problem, isolate the pertinent elements of the data, organize the obtainable information, form hypotheses, and test his hypotheses for solution of the problem.

The results of the testing of the problem solving ability of the hard of hearing group through the use of the Problem Box for statistically significant differences at the .05 level of significance necessitated the acceptance of the null hypotheses for some of the problems and the rejection of it for others. Only the null hypotheses 4 was rejected.

Hypothesis 1, stating that there is no statistically significant difference in the problem solving ability as measured by the number of the hard of hearing group versus the hearing group in solving or not solving each of the ten problems of the Problem Box, was accepted at the .05 level of significance for problems 1, 2, 4, 5, 7, 8, and 9 and rejected for problems 3, 6, and 10. Hypothesis 2, stating that there is no statistically significant difference in the problem solving ability as measured by the number of trials used by the hard of hearing group versus the hearing group to solve each of the ten problems of the Problem Box, was accepted at the .05 level of significance for problems 2, 5, 7, 8, and 9 and rejected for problems 1, 3, 4, 6, and 10. Hypothesis 3, stating that there is no statistically significant difference in the problem solving ability as measured by the number of the hard of hearing group versus the hearing group in solving each problem by verbal generalization versus the necessary number of consecutive red lights criterion, was accepted at the .05 level of significance for problems 1, 2, 3, 4, 6, 8, and 10 and rejected for problems 5, 7, and 9. Hypothesis 4, stating that there is no statistically significant difference between the mean number of problems solved by the hard of hearing group and the hearing group, was rejected at the .05 level of significance.

Conclusions

The hard of hearing children demonstrated by their performance on the problems presented by the Problem Box that their language deficiency had little effect upon the cognitive processes of problem solving as measured by the Problem Box. The hard of hearing children had difficulty in verbalizing their concept of alternation; however, their performance indicated that, by utilizing inductive and deductive reasoning, they formed and tested hypotheses and arrived at the solution of this problem. Where problems are designed so as to utilize the complete problem solving process, the hard of hearing children were not found to be inferior to hearing children of comparable age range and mental ability range.

Recommendations

Using the Problem Box, extensive testing of the hard of hearing children who attend schools where the oral method of teaching is predominent is recommended, since there has been little research of this kind done in this field. Hard of hearing children who attend schools where the manual and sign language are the method of teaching principally employed could be tested through the use of the Problem Box by qualified testers who are able to communicate proficiently with these children. Problem solving ability of these children could be compared with other studies where problem solving ability has been tested through the use of the Problem Box. In future studies, especially with the hard of hearing, audio-video tapes could be made of the subject during the testing period, thus allowing the tester to study at his leisure and in detail all clues given through the behavior of the subject as he relates to the problem presented to him and works out its solution. Administrators and teachers in the deaf education profession who observed the Problem Box indicated that they felt that the Problem Box had the potential for becoming a very effective instrument for presenting educational concepts and objectives to the hard of hearing children. Additional slides would need to be developed which would present the educational objectives and concepts. The problems presented by the slides could be arranged so that when the subject pushed the correct electrical button, the red light on the front panel of the Problem Box would come on, thus giving the subject immediate nonverbal positive reinforcement.

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APPENDIX

Table 4: Sex, Chronological Age, Number of Trials per Problem Total Trials, and Mean Number of Trials Used for Each of the Hard of Hearing Subjects.

Subject	Sex	C.A.	Number of Trials Used per Problem										Total No. of Trials Used	Mean No. of Trials Used
			1	2	3	4	5	6	7	8	9	10		
1	M	81	5	4	53	3	16	25	80	80	80	20	366	37
2	M	81	7	3	47	4	48	80	80	50	80	71	470	47
3	M	81	10	5	16	5	80	80	80	80	80	43	479	48
4	F	81	5	4	23	3	45	13	51	27	19	50	240	24
5	M	82	4	4	11	11	11	32	21	80	55	22	251	25
6	M	84	7	23	19	7	64	14	80	80	80	80	454	45
7	M	84	8	10	23	4	80	18	36	80	20	80	359	36
8	M	85	71	54	50	65	41	66	64	61	49	72	593	59
9	M	85	80	10	80	7	80	80	69	80	80	80	646	65
10	F	87	38	4	26	6	80	56	80	80	15	19	404	40
11	M	89	20	4	15	8	24	22	80	20	22	62	278	28
12	M	91	48	4	80	4	80	8	80	80	28	46	458	46
13	M	91	25	12	56	13	30	19	80	80	10	80	405	41
14	F	92	49	11	55	10	13	43	80	11	75	80	427	43
15	M	92	34	5	21	4	14	80	80	80	80	80	478	48

Table 4--(Continued)

Subject	Sex	C.A.	Number of Trials Used per Problem 1	2	3	4	5	6	7	8	9	10	Total No. of Trials Used	Mean No. of Trials Used
16	M	95	18	3	14	5	17	27	40	8	15	25	172	17
17	M	95	80	16	39	10	13	20	80	19	32	15	324	32
18	M	96	6	4	80	8	80	18	80	80	80	24	460	46
19	F	101	80	6	68	12	24	80	80	41	58	80	529	53
20	M	102	8	7	58	8	9	80	53	24	28	55	330	33
21	M	103	66	4	68	7	13	31	52	80	80	80	481	48
22	F	120	80	5	70	11	80	15	80	80	80	80	581	58
23	M	123	8	14	33	4	43	39	80	68	78	64	431	43
24	F	125	14	54	54	6	24	19	80	11	80	38	380	38
25	M	125	5	4	17	4	12	7	80	11	80	26	246	25
26	M	126	24	4	80	4	13	10	29	10	80	80	334	33
27	M	127	6	4	80	4	5	79	80	14	80	80	432	43
28	M	129	80	6	28	6	80	77	80	80	80	80	597	60
29	M	131	7	4	35	4	14	26	80	66	80	80	396	40
30	F	131	5	4	79	6	24	7	80	80	80	79	444	44
31	M	132	6	12	80	12	37	78	55	31	66	27	354	35
32	M	136	20	2	80	4	6	28	80	8	35	51	314	31

Table 4--(Continued)

Subject	Sex	C.A.	Number of Trials Used per Problem 1	2	3	4	5	6	7	8	9	10	Total of Trials Used	Mean No. of Trials Used
33	F	138	55	9	36	10	13	31	80	11	36	80	361	36
34	F	145	10	4	23	10	7	28	80	14	80	25	281	28
35	F	147	6	4	21	4	10	7	72	13	10	14	161	16
36	M	149	9	2	80	3	18	22	80	5	64	66	349	35
37	F	149	5	8	80	3	8	80	80	18	52	55	389	39
38	F	152	4	3	9	4	74	7	11	80	10	65	267	27
39	F	152	4	4	32	4	80	9	80	80	80	80	453	45
40	F	153	9	5	38	4	4	40	26	8	6	45	185	19
41	F	153	5	4	35	5	80	10	80	7	47	80	353	35
42	F	153	4	4	68	4	49	40	8	43	17	20	257	26
43	F	153	80	10	77	4	36	73	80	80	80	80	600	60
44	M	155	15	6	80	16	80	25	80	80	22	32	436	44
	Mean for Group:		25.68	8.48	48.14	7.73	37.70	37.48	67.89	48.16	53.16	56.61	391.02	
	Standard Deviation:		27.35	10.75	24.89	9.30	28.72	26.83	21.02	31.28	28.18	24.15		

Table 5: Percentage of the Hard of Hearing Group Solving Each Problem, with Problems Listed in Rank Order of the Highest to the Lowest Percentage of the Group Solving Each Problem, Showing Mean Number of Trials Used and Standard Deviation for Each Problem

Problem Number	Percentage Passing	Mean Number of Trials Used	Standard Deviation
4	100.0	7.73	9.30
2	100.0	8.48	10.75
1	85.9	25.68	27.35
6	83.6	37.48	26.83
3	77.3	48.14	24.89
5	75.0	37.70	28.72
10	63.6	56.61	24.15
8	56.8	48.16	31.28
9	56.8	53.16	28.18
7	31.3	67.89	21.02

Table 6: Numbers of Problem Solved and Total Number of Problems Solved on a Simple Pass-Failure Basis for Each of the Hard of Hearing Subjects

Subject	Problems Solved	Total Solved	Subject	Problems Solved	Total Solved
1	1,2,3,4,5,6,10	7	23	1,2,3,4,5,6,8,9,10	9
2	1,2,3,4,5,8,10	7	24	1,2,3,4,5,6,8,10	8
3	1,2,3,4,10	5	25	1,2,3,4,5,6,8,10	8
4	1,2,3,4,5,6,7,8,9,10	10	26	1,2,4,5,6,7,8	7
5	1,2,3,4,5,6,7,9,10	9	27	1,2,4,5,6,8,	6
6	1,2,3,4,5,6	6	28	2,3,4,6	4
7	1,2,3,4,6,7,9,10	8	29	1,2,3,4,5,6,8	7
8	1,2,3,4,5,6,7,8,9,10	10	30	1,2,3,4,5,6,10	7
9	2,4,7	3	31	1,2,4,5,6,7,8,9,10	9
10	1,2,3,4,6,9,10	7	32	1,2,4,5,6,8,9,10	8
11	1,2,3,4,5,6,8,9,10	9	33	1,2,3,4,5,6,8,9	8
12	1,2,4,6,9,10	6	34	1,2,3,4,5,6,8,10	8
13	1,2,3,4,5,6,9	7	35	1,2,3,4,5,6,7,8,9,10	10
14	1,2,3,4,5,6,8,9	8	36	1,2,4,5,6,8,9,10	8
15	1,2,3,4,5	5	37	1,2,4,5,8,9,10	7
16	1,2,3,4,5,6,7,8,9,10	10	38	1,2,3,4,5,6,7,9,10	9
17	2,3,4,5,6,8,9,10	8	39	1,2,3,4,6	5
18	1,2,4,6,10	5	40	1,2,3,4,5,6,7,8,9,10	10
19	2,3,4,6,8,9	6	41	1,2,3,4,6,8,9	7
20	1,2,3,4,5,7,8,9,10	9	42	1,2,3,4,5,6,7,8,9,10	10
21	1,2,3,4,5,6,7	7	43	2,3,4,5,6	5
22	2,3,4,6	4	44	1,2,4,6,9,10	6

Mean Number of Problems solved by group = 7.32.
Standard Deviation: 1.79.

Table 7: Numbers of Problems Solved, and Total Number of Problems Solved by Verbal Generalization for Each of the Hard of Hearing Subjects.

Subject	Problems--Verbal Generalizations Achieved	Total Solved	Subject	Problems--Verbal Generalizations Achieved	Total Solved
1	1,2,3,4,5,6,10	7	23	1,2,3,4,5,6,10	7
2	1,2,3,4,5,8	6	24	1,2,3,4,5,6,8	7
3	1,2,3,4	4	25	1,2,3,4,6,8	6
4	1,2,3,4,5,6,7,8,9,10	10	26	1,2,4,5,6,7,8	7
5	1,2,3,4	4	27	1,2,4,5,6	5
6	1,4	2	28	2,4	2
7	1,2,3,4,6,7,9	7	29	1,2,3,4,5,6,8	7
8	1,2,3,4,6,8,10	7	30	1,2,4,5,6	5
9	2,4	2	31	1,2,4,5,10	5
10	1,2,3,4,6	5	32	1,2,4,5,6,8,9	7
11	1,2,3,4,5,6,8,9	8	33	1,2,3,4,5,6,8,9	8
12	2,4,6,9	4	34	1,2,3,4,5,6,8,10	8
13	0	0	35	1,2,3,4,5,6,7,8,9	9
14	0	0	36	1,2,4,5,6,8,9	7
15	1,2,4,5	4	37	1,2,4,5,8,9	6
16	1,2,3,4,5,6,7,8,9,10	10	38	1,2,3,4,5,6,7,9	8
17	2,3,6,8,9	5	39	1,2,4,6	4
18	1,2,4,6	4	40	1,2,3,4,5,6,7,8,9,10	10
19	2,3,4	3	41	1,2,3,4,6,8	6
20	1,2,3,4,5	5	42	1,2,4,5,6,7,8,9	8
21	1,2,3,4,5,6,7	7	43	4,5,6	3
22	2,3,6	3	44	1,2,4	3

Table 8. Hearing Loss for Each of the Hard of Hearing Subjects as Shown by Available Audiological Records*

Etiology	Air Conduction													
	Right Ear							Left Ear						
/Frequency-	125	250	500	1000	2000	4000	8000	125	250	500	1000	2000	4000	8000
1. Rubella		55	75	80	75	75	65	70	75	90	85	80	70	
2. Rubella		75	90	95	75	65	75		60	80	75	60	55	65
3. Congenital		65	75	85	85	95			60	70	85	85	90	
4. Congenital		55	58	60	60	70	80		58	58	60	60	65	85
5. Drug Damage		80	85	100	105	105	NR		85	90	105	NR	NR	NR
6. Unknown		75	70	90	95	95	NR		80	85	85	85	90	NR
7. Unknown	10	25	35	60	65	65	75	15	25	40	55	60	60	75
8. Unknown		20	35	40	55	50	55		20	35	40	50	40	60
9. Rubella	NR-----	-----	-----	-----	-----	-----	-----	75	85	85	85	90	70	85
10. Rubella	Not Available - Profoundly Deaf													
11. Meningitis	65	80	85	95	90	80	75	NR	80	85	100	100	90	85
12. Rh Factor	45	75	85	105	NR-----	-----	-----	35	50	85	75	105	NR-----	-----
13. Rubella		80	NR-----	-----	-----	-----	-----		80	NR-----	-----	-----	-----	-----
14. Rh Factor	75	75	85	95	NR-----	-----	-----	70	75	85	95	NR-----	-----	-----
15. Unknown		50	80	95	95	NR-----	-----		50	70	95	95	NR-----	-----
16. Rh Factor	80	90	105	90	100	NR-----	-----	80	NR	105	85	NR-----	-----	-----
17. Unknown		80	85	100	95	70	65		80	85	80	75	70	65
18. Unknown	60	75	85	100	105	NR-----	-----		40	75	90	105	110	NR
19. Unknown		70	90	95	90	80			60	65	70	50	70	
20. Meningitis	75	50	60	90	80	70	55	65	NR	NR	NR-----	-----	-----	-----
21. Prematurity-- High fever at Birth	NR	90	100	100	NR-----	-----	-----	NR	90	100	100	NR-----	-----	-----

*All data are Air Conduction Hearing Thresholds in Decibel re ANSI.
NR = No Response.

Table 8--(Continued)

Etiology /Frequency-	Air Conduction Right Ear 125	250	500	1000	2000	4000	8000	Left Ear 125	250	500	1000	2000	4000	8000
22. Unknown	30	40	50	50	55	60	25	25	40	50	50	55	60	15
23. Unknown	65	60	80	85	NR----------			60	60	75	85	NR----------		
24. Unknown	75	90	110	110	110	100	90	NR------------------------------						
25. Spinal Meningitis	65	68	72	72	60	70	80	68	70	72	75	85	90	90
26. Unknown	NR------------------------------							NR------------------------------						
27. Unknown	68	70	70	85	95	95	100	65	70	70	80	95	100	110
28. Unknown	45	55	90	90	95	95	80	35	50	75	85	95	95	60
29. Unknown	65	72	70	70	72	75	78	68	75	72	70	65	65	65
30. Measles-High fever	80	90	95	NR----------			90	80	90	95	NR----------			90
31. Rh Factor	NR-----		105	NR---------------				NR-----		100	NR---------------			
32. Unknown	30	40	55	75	75	85	90	30	55	90	100	90	100	90
33. Rubella	30	35	65	70	100	105	80	45	50	65	70	75	75	60
34. Rubella	NR------------------------------										90	100	80	80
35. Unknown		40	55	75	85	95	NR		40	60	80	80	85	NR
36. Unknown	25	35	55	65	70	75	80	30	40	55	75	75	75	80
37. Genetic Factor	65	72	75	80	80	82	82	68	70	75	60	60	90	90
38. Unknown	100	95	95	85	85	70	70	100	100	102	105	110	110	110
39. Rubella	75	80	80	83	85	90	95	82	90	95	100	100	110	110
40. Rubella	NR	80	105	NR---------------				NR	85	110	NR---------------			
41. Possible Measles	85	90	95	100	100	110	110	80	90	92	95	100	110	110
42. Rubella	75	82	85	90	90	92	95	68	70	72	78	65	65	70
43. Rubella	72	80	85	85	90	95	98	68	70	72	75	80	80	90
44. Genetic Factor	60	70	75	80	82	85	90	62	65	65	68	70	70	75

NR = No Response

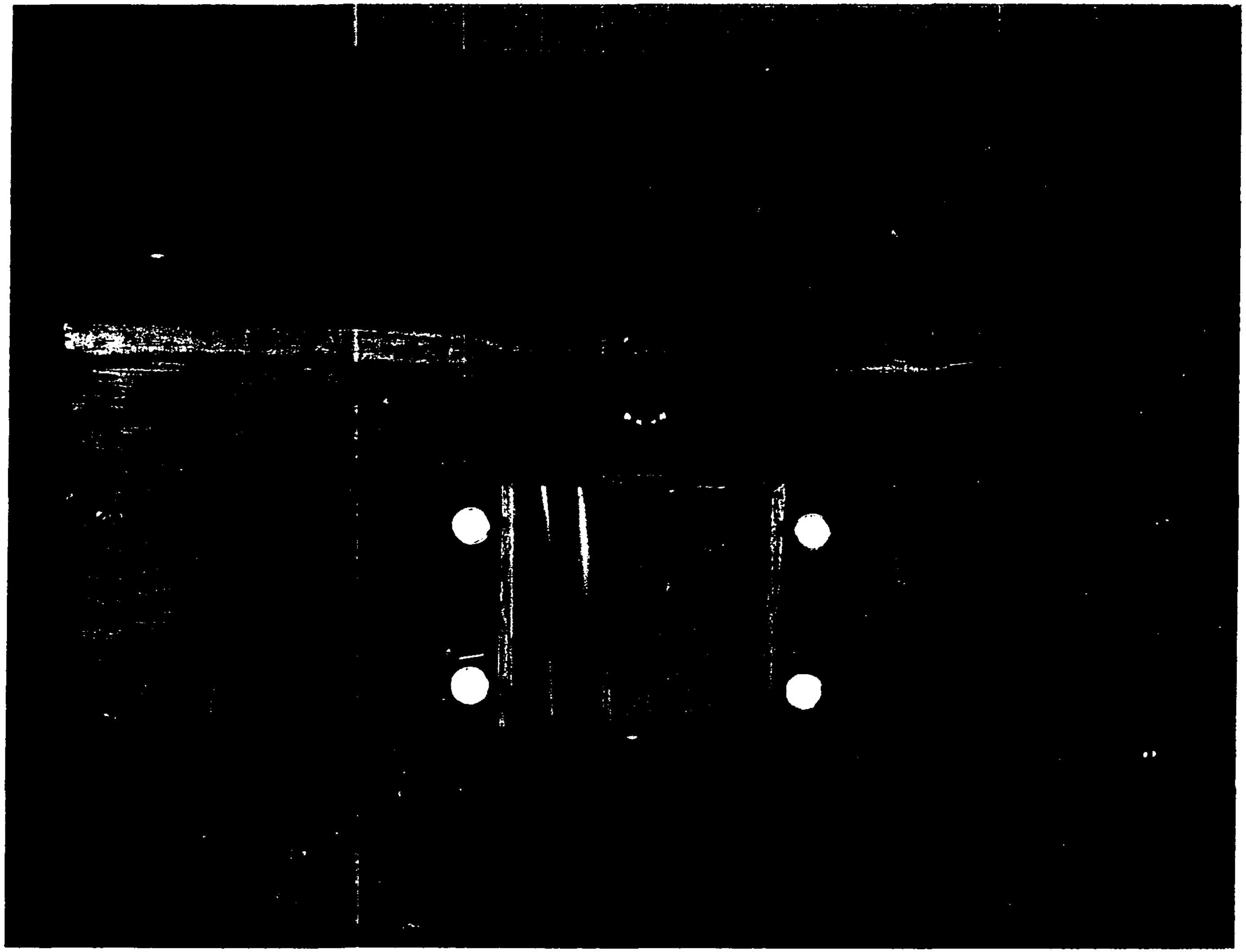


Figure 1. Front view of the Problem Box

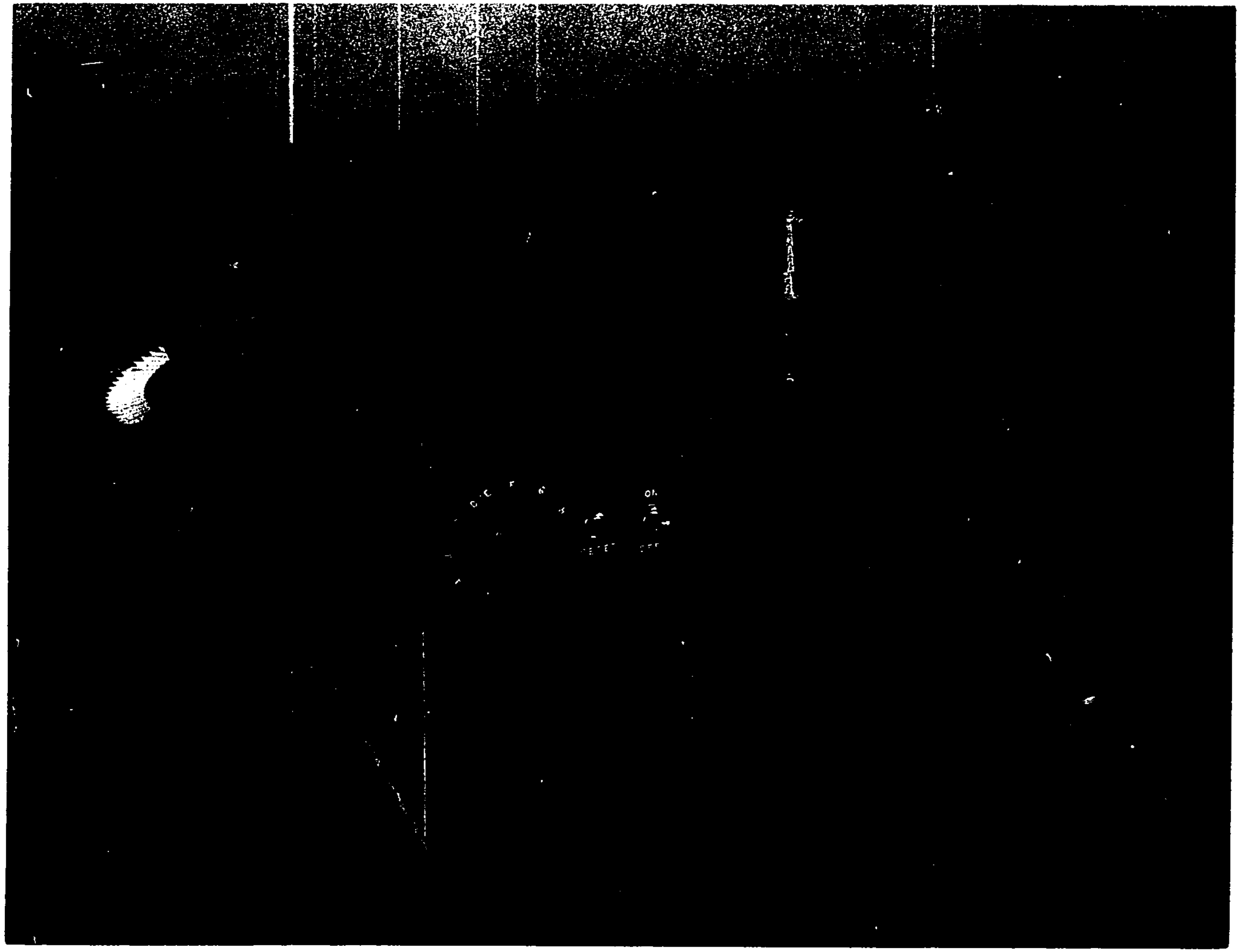


Illustration 2. Side view of Heath Problem Box

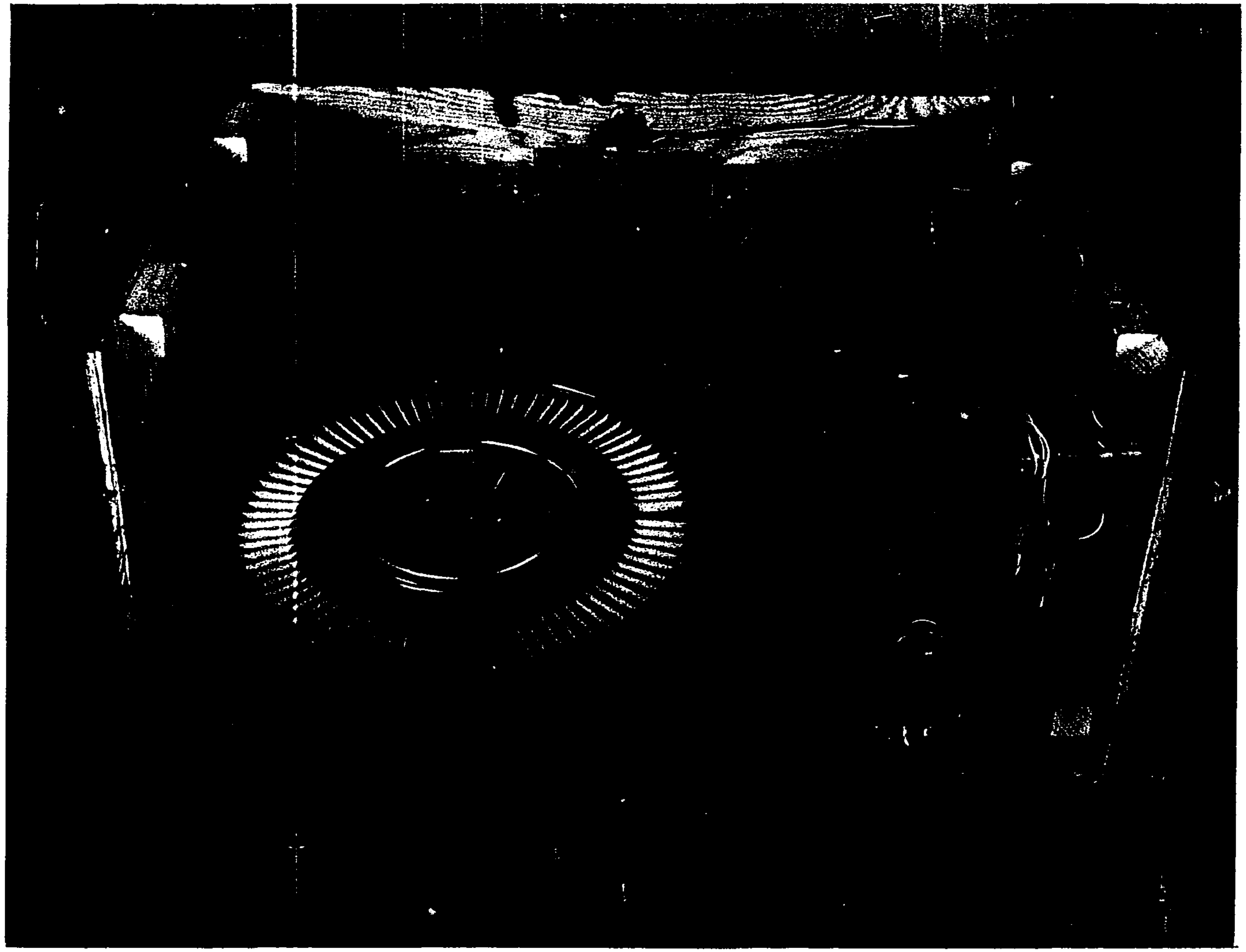


Illustration 3. Inside mechanism of Heath Problem Box

Problems 1,2,3

		ws	wt
ws	wt		
wt			
	ws	ws	wt
	ws	wt	
wt			ws
ws	wt	wt	ws
wt	ws		ws
		wt	
		ws	
wt	ws		wt
ws			wt
	wt	ws	
ws	wt	wt	ws
	wt		wt
ws		ws	
	ws	wt	ws
wt			

Problem 4

wt	gs		
		wt	gs
	wt		gt
gs		ws	
wt	gs		
		ws	gt
			gt
ws	gt	ws	
	ws		ws
gt		gt	
gs	wt		gs
		wt	
	wt		
gs		wt	gs
gs			ws
	wt	gt	
ws	gt		
		gs	gt
gt	ws		gs
		wt	

Problems 5,8,9,10

rs	rt	gt	
			gs
	rs	gt	gs
rt			
gt	gs	rs	
			rt
gt			gs
	gs	gt	
rt	rs	gs	gt
gs			rt
	gt	rs	
rt	rs	rs	rt
gs	gt		rs
		gt	
	rt		
rs		gs	gt
rt	rs		rt
		rs	

Problems 6,7

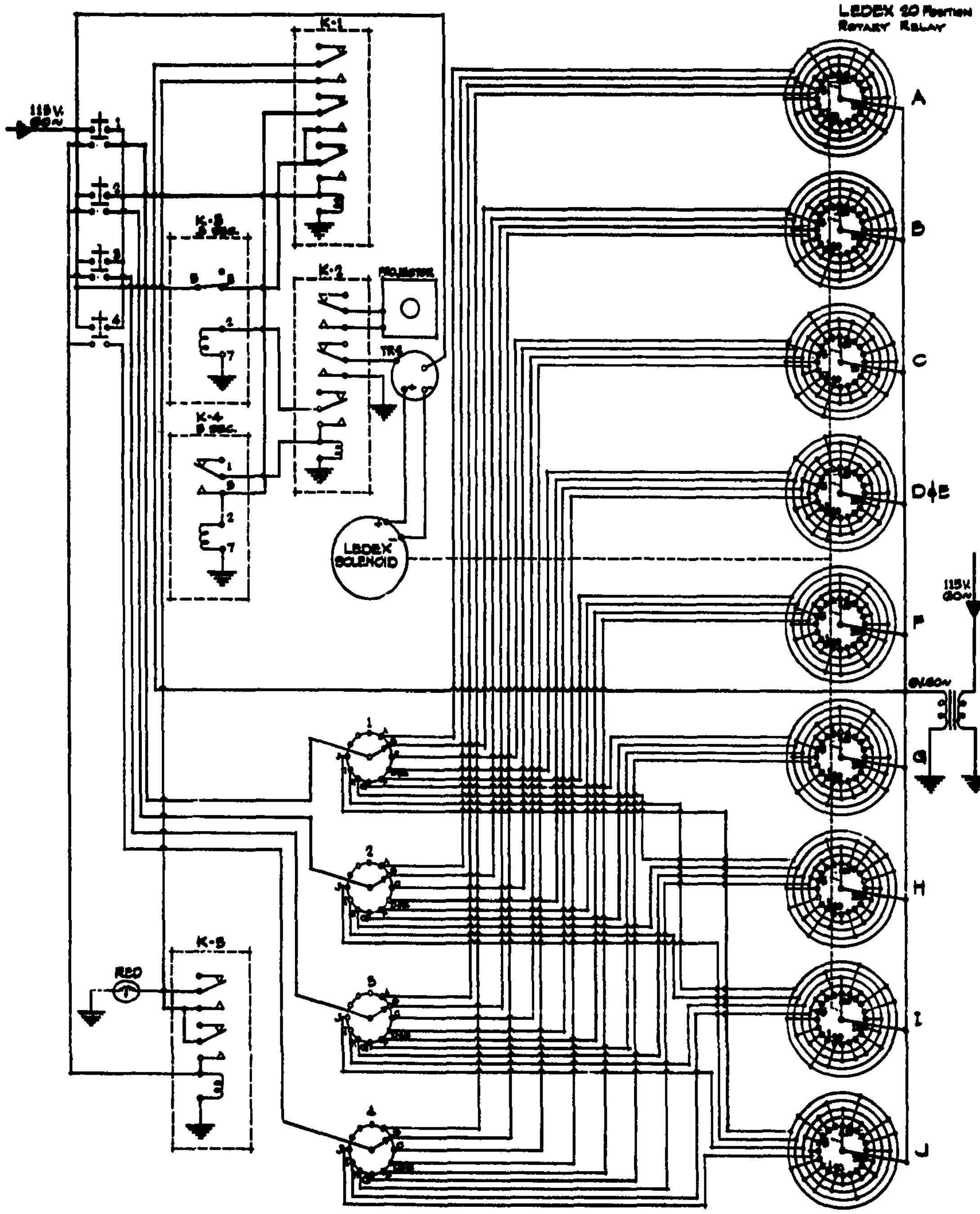
		rs	gt
gs	rt		
gt			
	rs	rs	gt
	gs	gt	
rt			rs
rs	gt	rt	gs
gt	rs		rs
		gt	
		gs	
rt	gs		rt
gs			gt
	rt	rs	
rs	gt	gt	rs
	rt		gt
gs		rs	
rt		rt	gs
	gs		

<u>Code for colors of</u>
<u>Geometric figures</u>
w equals white
g equals green
r equals red

<u>Code for shapes of</u>
<u>Geometric figures</u>

t equals triangle
s equals square

Figure 1. Order of Presentation of the Slides for the Ten Problems



SCHEMATIC DIAGRAM OF
HEATH PROBLEM BOX

Figure 2

Oklahoma City, Oklahoma
January 5, 1971

Dear Jim,

I am glad you are planning to do further study using the Problem Box. Please feel free to use the data and other materials from my dissertation. If I can help you in any other way, just let me know. I will be interested in seeing the results of your study.

Sincerely

Paul A Heath

Paul Allen Heath, Ed. D.